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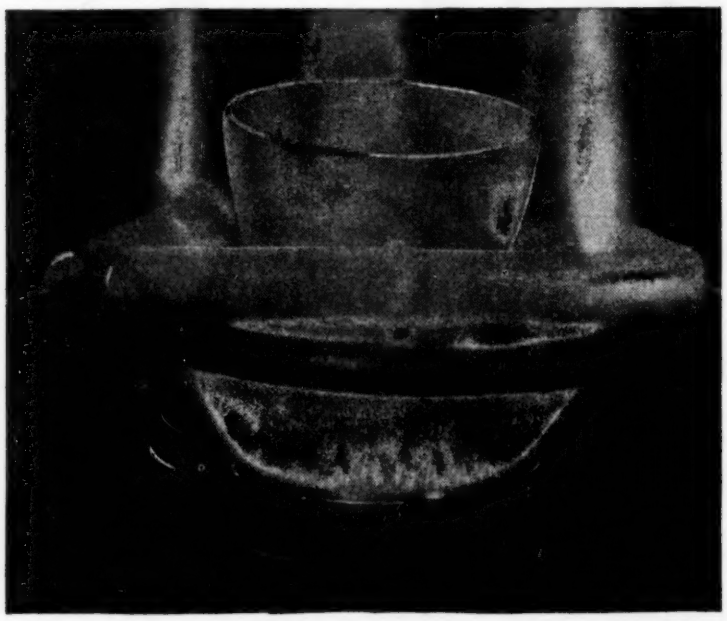

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SCIENCE

Vol. 104, No. 2690 **Friday, 19 July 1946**

Thermodynamics of an Ice Age: The Cause and Sequence of Glaciation

Gilbert N. Lewis

University of California, Berkeley

MANY OF THE OLDER THEORIES of an Ice Age assumed that glaciation was due to a general lowering of terrestrial temperatures—for example, by diminished solar radiation. It has, however, become evident that glacial periods have often been associated with intense precipitation in all parts of the world, leading to the formation of large lakes, some of which are now nearly or quite dry. Unless precipitation was local, it must have resulted from abnormally high evaporation; hardly reconcilable with lower temperatures.

Jeffreys (*4*) has pointed out in his critique of glaciation theory that the only sure correlation between glaciation and other known phenomena is that each great Ice Age has been ushered in by a period of unusual land and mountain formation.

This is not merely an empirical observation. It was made plausible by Ramsay (*6*) that great land elevation should produce conditions favorable to glaciation. Brooks (*1*) developed this idea further and even claimed that in one of the great Ice Ages the peculiar geography of the time was able to produce a widespread glaciation centering in the tropics.

Admitting that large and high land masses afford a predisposition toward glacier formation, we must still look for the cause of the individual advances and recessions of the glaciers during single Ice Ages, within the last of which, at least, no great, discontinuous, geographical changes are believed to have occurred.

A new and ingenious theory of Sir George Simpson (*7*) attributes an Ice Age to an *increase* in solar radiation. He believes that glaciations come in pairs, each pair being caused by a single rise and fall of solar radiation, as shown in his diagram, one of the identical halves of which is reproduced in Fig. 1. He assumes that the four main glaciations of the Pleistocene period were caused by two such periods of intensified solar radiation, one of which is shown in Curve I. The average temperature of the world is assumed to follow a similar course (Curve II). Curve III indicates the course of average annual precipitation, and Curve IV represents, according to Simpson's theory, the total amount of glacial ice, the two maxima representing one pair of the main glaciations.

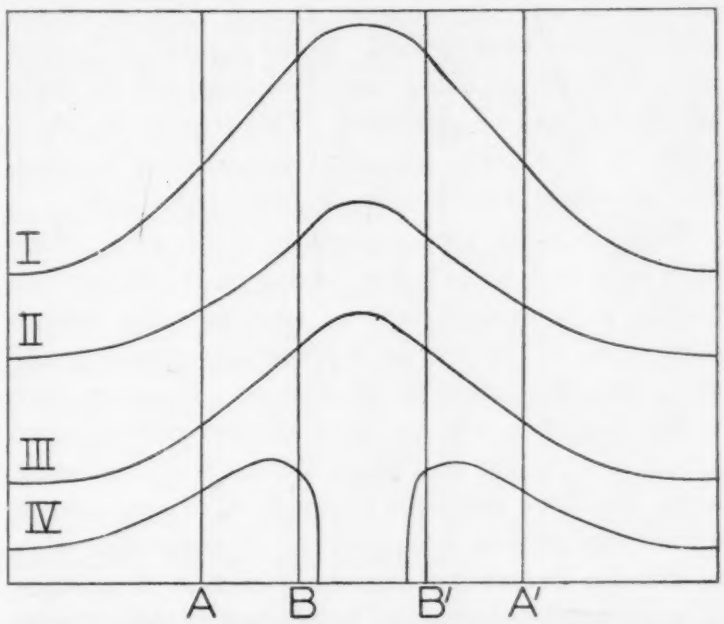

FIG. 1. Simpson's diagram: I—Solar radiation; II—Temperature; III—Precipitation; IV—Total ice.

In physics and chemistry, with the single exception of the phenomenon of momentum, there is no such thing as habit: a process is determined solely by present conditions. In meteorology the only momenta that need be considered are those of air and ocean currents, and since these momenta would be dissipated in a few weeks or months if their causes were removed, a criterion of the truth of any theory must be that the occurrences over a long period of years are due only to the conditions then prevailing. The above theory does not meet this criterion. According to the diagram, at A and A′ there are identical conditions of radiation, temperature, average precipitation, and total glaciation. If the glaciers are increas-

Dr. Lewis died 23 March 1946, shortly after submitting this, his last paper.

ing at one of these points, they must be increasing at the other. But this is not the state of things shown in the figure. Again, at B and B′, under identical conditions, the figure shows glaciers to be rapidly receding at the first point and rapidly advancing at the other. While we have not proved that an increase in solar radiation might not give rise to a glaciation, physical chemistry denies that the sequence of events can accord with Simpson's theory.

There are still adherents (*9*) of the astronomical theories of glaciation initiated by Croll (*3*), and there is no doubt that any change in the orbit of the earth or in the direction of the polar axis, as well as any change in solar radiation, must produce marked changes in our climate. Nevertheless, it remains doubtful whether any such changes have been of sufficient magnitude to produce a great glaciation. It seems more likely that the cause of glaciation is to be found in purely terrestrial happenings.

Any discussion of an Ice Age must deal with a whole complex of phenomena which includes not only the intense pluvial and glacial periods but also long periods of cool, dry climate, during which the great loess deposits were formed. These periods of drought were believed by Penck and Brückner (*5*) to begin before the peak of glaciation. This conclusion, which seems at first sight somewhat remarkable, we shall find in accord with physicochemical deductions.

Regarding the major glaciations, of which there have been four since the beginning of the Pleistocene period, it is evident that as long as polar icecaps exist there will always be fluctuations, increasing and decreasing the extent of glacial ice. However, each major glaciation was an event of such colossal magnitude, several per cent of all the water of the oceans being deposited upon the ice fields, that some sort of a runaway process is suggested. It seems that when a climatic fluctuation exceeds a certain magnitude, a condition of instability is reached in which some self-accelerating process makes glaciation proceed for some time without hindrance. We must now look for possible causes of such a phenomenon.

Two Self-accelerating Processes Conducive to Glaciation

Process A. One of the meteorological phenomena having great influence upon the formation of glaciers was mentioned by Croll (*3*) and has since been widely discussed. When sunlight falls upon land or sea, it is largely absorbed, but, when the surface is covered with ice and snow, the albedo (reflectivity) is much higher, reaching 0.80 for fresh snow or hoarfrost. On the other hand, such surfaces are nearly black bodies for the radiant energy of very long wave length, which almost alone constitutes the thermal radiation from the earth's surface. Thus, when land or ocean, without much change of temperature, becomes covered with ice and snow, energy is emitted at about the same rate as without such covering, but the energy received from the sun is only from one-half to one-fourth as much. The surface and the neighboring air become much colder, and, as this cold air spreads, more ice is formed in the neighborhood. Thus, every glacier tends to spread, such a spreading being limited only by circulation of air from warmer regions. This tendency of ice to produce more ice is illustrated by the fact that minor climatic changes produce major changes in the amount of ice in the Barents Sea (*8*).

With reference to Brooks' (*1*) idea that a great glaciation may have occurred in the tropics, we may inquire what would happen if the whole surface of the earth—land and water—were covered by ice and snow. Let us assume, as a hypothetical case, that the whole surface is covered with snow or rime with an albedo of 0.80, that momentarily it has a temperature just below the freezing point, and that the sky is free from clouds. Under these circumstances the rate of emission of thermal energy would greatly exceed the energy received from the sun. The temperature, even at the equator, would fall greatly. In making this calculation we have used numerical data occasionally from the work of Sverdrup, Johnson, and Fleming (*8*) but chiefly from Brunt's meteorology (*2*).

Under ordinary conditions of cloudiness and albedo, Q_A, the average solar radiation absorbed on a horizontal surface, at the equator, is 0.34 units (small cal./cm.^{2}/min.). The thermal emission, Q_E, averages 0.30 units. The difference, $Q_C = 0.04$, by processes of evaporation and air circulation, is carried to those parts of the earth in which the energy emitted exceeds the energy received from the sun. On the completely glaciated world as we have pictured it, the solar radiation at the surface would be much greater because of the lack of clouds. Without clouds, the amount of solar energy reaching one horizontal square centimeter at the equator (averaged through the year) is obtained by subtracting from the solar constant 9 per cent for reflection from the atmosphere and 5 per cent for absorption by ozone, and then integrating over all angles of incidence of the radiation. The result is 0.50 units. If the albedo is as high as 0.80, only 20 per cent of this radiation is absorbed, Q_A becoming 0.10.

The amount of heat radiated under these same circumstances is hard to estimate. Using Brunt's empirical equation for the effective surface radiation as a function of the humidity of the surface air, and taking the partial vapor pressure at the surface as

the vapor pressure of ice at 0° C., we find that the effective radiation would be 0.34 times the radiation given by Stefan's law at 0° C., which makes Q_E, the average energy emitted from the surface, approximately 0.16. Since Brunt's equation admittedly does not give a reasonable extrapolation to zero humidity, it is evident that a good deal of the radiation from the atmosphere back to the earth must be due to moisture high in the atmosphere, where humidity measurements cannot readily be made. Under the conditions of complete glaciation this moisture content at high altitudes would also presumably be reduced, and the true loss by surface radiation would then be considerably greater than that just obtained—perhaps 0.24. However, even if the low value, 0.16, is used and energy lost by atmospheric circulation, ignored when this is compared with 0.10 for the heat received, it is apparent that there would be a great cooling, even at the equator.

However, old glacial ice often has an albedo much lower than that of snow. If an albedo is 0.60, Q_A would be 0.25. Whether such a surface would become colder, or would melt, depends upon the value taken for Q_E. If the albedo should drop to 0.50, or even lower, because of some deposit of volcanic dust, Q_A would certainly be greater than Q_E, and the glacial ice would melt. If this occurred over the ocean, even in a limited area, the water would tend to spread, for this would also be a self-accelerating process. It seems likely, therefore, that even a completely glaciated world would eventually return to normal conditions.

By itself the albedo process, pronounced as it is, seems inadequate to produce the runaway phenomenon of a great glaciation. If a glacier spreads, not only will the average temperature decrease, but the periphery will move nearer to the tropical regions. Thus, in two ways the average temperature change per degree of latitude will increase. It is upon this rate of change of temperature with the latitude that all atmospheric circulation basically depends. Therefore, when a glacier advances, there will be an increase in the general circulation of the atmosphere, and this will increase the amount of heat carried from lower to higher latitudes. This would seem to be a sufficient automatic method of preventing an indefinite expansion of the ice fields, were it not for another phenomenon that must now be considered.

Process B. This process is self-accelerating and not self-limiting, so that, when once started, it should go on increasingly until some other factor brings it to an end. The process has the effect of a specific sort of siphoning of water from the warm oceans to a glacier. In using such terms, however, we must not think of anything spectacular. It is the main thesis of this paper that the remarkable phenomenon of a great glaciation is due to slow, cumulative effects of small but continued departures from normal climatic conditions.

A large ice field is the source of an extended, nearly homogeneous, and very cold and dry air mass. As this moves and ultimately interacts with the warm and humid air of lower latitudes, it causes precipitation, some of which, falling at or near the periphery, will produce a temporary or permanent extension of the glacier. There will also be precipitation over the whole ice field. Even the most humid airs of the tropics retain 20 to 30 per cent of their moisture at 0° C., but most of this residual moisture can be precipitated, often as light snow or ice fog, over the interior of the ice fields, where far lower temperatures are attained.

The interaction of air masses as determined by continents, oceans, and the seasons is not our present concern. We must consider here average changes, not between summer and winter, but over centuries and millennia. The effect of glacial expansion must be to produce a more extended, more homogeneous, colder, and drier air mass. Thus, while an increasing percentage of total evaporated water will condense upon the ice field, the greater mass of drier air, as it moves away from its source, will diminish the average humidity of the whole atmosphere. This drier air over the warm oceans will cause an increased evaporation, which will also be aided by greater air velocities, if the increase of general atmospheric circulation that has been mentioned causes generally greater windiness. We thus have a greater precipitation on the ice fields, greater evaporation from the oceans, but less humidity and less precipitation throughout the rest of the world. This siphoning effect should increase as the glaciers advance, to be stopped only by some factor not yet considered.

Probable Immediate Cause of a Great Glaciation, and the Sequence of Glacial Events

The stage seems to be set for an Ice Age by unusual land and mountain formation, and under these favorable circumstances, as indicated above, there are two self-accelerating processes which may permit relatively minor climatic changes to produce a major glaciation. Because of the runaway character of such a glaciation we cannot decide with any certainty what sets off the event. However, there is one type of meteorological change that presumably initiated at least some of the major glacial advances and that certainly must produce such a result if the change is of considerable magnitude.

The extension of a glacier may be produced not only by a lowering of the local temperature but also

by an increase in precipitation, and it would seem that a long-continued increase of precipitation over the glaciers, amounting to a few per cent, could produce a sufficient glacial growth to start the runaway process. Such an increased precipitation would result if the total net evaporation from the oceans were increased correspondingly. An examination of the rate of evaporation from the oceans in various parts of

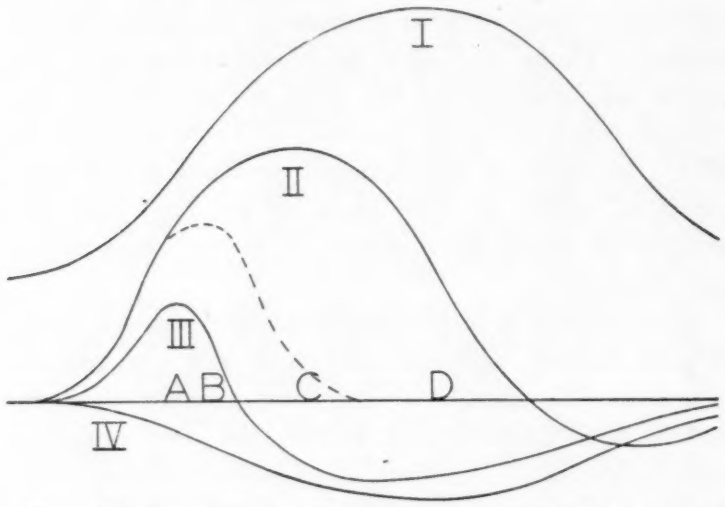

FIG. 2. Sequence of glacial events: I—Total ice; II—Evaporation; III—Precipitation, far from glacial area; IV—Temperature, far from glacial area.

the world (*8*) reveals that many small factors must be involved. Primarily, the evaporation at any point depends upon the surface temperature of the ocean and the dryness and velocity of the air. Only slight changes in these factors would cause a considerable change in the evaporation. For example, if the velocity and humidity of the air should remain constant, we can imagine a small upthrust at the bottom of an ocean to divert a warm current into a region of greater windiness or to spread the warm water over a larger surface. At present the region of greatest net evaporation per unit surface is the Atlantic on either side of the equator, where conditions would seem not unfavorable for such a change. By such an effect, or another, there are presumably fluctuations in the average evaporation and corresponding fluctuations in the precipitation upon the ice fields. When an increase in precipitation exceeds a certain value, we may assume that the runaway process may be initiated.

It is known that a great glaciation is no single event and that there are numerous advances and retreats, but for the sake of simplicity we shall ignore all of these fluctuations and attempt to find the general consequences of a period of high average evaporation. However, if a major glaciation consists of a number of phases, in each of which there is a great advance and retreat of the glaciers, it would seem that the following deductions would be approximately applicable to each phase separately.

Let us consider a time, something like our own climatically, in which there are fluctuations in evaporation, none of which, however, are great enough to have major consequences. Finally there comes a period of great evaporation, represented in Fig. 2 by the beginning of Curve II. It would, by itself, have a maximum at some point, B, and return to normal according to the dotted curve. However, at about A the runaway process begins, the course of evaporation following the full Curve II. The amount of glacial ice would then follow some such curve as I, and the temperature at some point far from the ice fields, such a curve as IV. As soon as the siphoning begins, precipitation at some point far from the ice fields (Curve III) begins to fall and soon becomes less than normal. The resulting long period of drought, beginning some time before maximum glaciation, continues until all conditions return gradually to normal. The reason for the cessation of the whole process must be that eventually the great loss of solar energy, due to the albedo effect, causes a general lowering of temperature that ultimately reaches the surface waters of the tropics (point C). Because of the great change in rate of evaporation with temperature, presumably these surface temperatures would need to be lowered only 1° or 2° C. in order to produce sufficient diminution in evaporation to bring the whole glacial epoch gradually to a close.

The schedule of events during a glacial epoch are more complicated when there are large fluctuations of advance and retreat of the ice. Local climatic events may also be governed by special conditions. Fig. 2 shows the probable sequence of events for the world as a whole. First comes the pluvial period, during which it is probable that wide glaciation occurs on the tropical mountains. On the other hand, it seems likely that the Alps, lying so close to the main glaciers, have a chronology approximating that of the Arctic icecap. The pluvial period is followed by a long period of cool and dry climate which precedes and continues through the peak of glaciation itself. Finally, the whole process wanes, the initial conditions being gradually restored.

It has not been proved that every major glaciation is preceded by a pluvial period. There may be some combination of other factors than evaporation that could start the siphoning process. In such a case the sequence would begin with a period of increasing drought, followed by the peak of glaciation. In either case physicochemical considerations lead to the same conclusion as that reached by Penck and Brückner—the peak of glaciation is preceded by a period of cool, dry climate and continues nearly to the end of glaciation. If there is a pluvial period

it must occur, not at the end, but near the beginning of the glaciation.

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Association Affairs

West Point and the AAAS

Sidney Forman, *Archivist*

United States Military Academy, West Point, New York

A RECENTLY CATALOGUED GIFT to the United States Military Academy library discloses a heretofore unknown close relationship between West Point and the foundation of the AAAS. The gift consists of printed records published during the years 1830–32 by the American Association for the Promotion of Science, Literature, and the Arts.[1] This society, the records reveal, was formed on 16 May 1829 by a group of 24 cadets with the initial title of The Associate Society of West Point. Within a year it contained 88 members, including nearly all of the Academy professors and assistant professors. The membership published a grandiose plan to advance every phase of American culture and achieve a national organization similar to the French Institute or the Royal Society of London but more broadly and democratically conceived. They had in mind the general promotion of knowledge through associate organizations in every town and village in the United States and, in addition, suggested several projects which might be undertaken by the national society:

> They might advance the cause of education, by selecting the best books for general use, and by introducing a uniform and superior system of instruction. They might define and fix the pronunciation of our language, so as to secure a perfect uniformity therein, throughout the Union. They might promote our national literature by criticizing American publications and recommending valuable works to general patronage. They might extend the limits of science by new experiments and discoveries, and enrich the useful arts by important improvements and inventions. They might collect and diffuse much practical information and useful knowledge by periodical publications. Finally, they would unite the feelings and interests of all parts of our republic and thus cement more firmly that confederacy which has been the source of our civil, political, and religious freedom.

Soon after the formation of the first group at West Point and the election of a corresponding committee, an Associate Society of Schenectady was organized at Union College. This included 94 student and faculty members. A similar group was set up at the University of Nashville, Tennessee, and others at Utica, New York; Miami University, Oxford, Ohio; Rochester, New York; New York City; Jewett City, Connecticut; Gallatin, Tennessee; and Newport, Rhode Island.

There is no record of what happened to the society or its activities after 1832. The interesting connection with the AAAS is shown in the fact that many of the prime movers of the West Point group were among the charter members and founders of the Association.[2] One of the more distinguished examples was William W. Mather, who was assistant professor of chemistry, mineralogy, and geology at West Point from June 1829 to June 1835, during which time the West Point association flourished. He was one of those who in 1840 formed the original Association of American Geologists, which in 1847 resolved itself into the AAAS. Roswell C. Park, a leading spirit in forming the West Point society in his cadet days, became a charter member of the Association in 1848. It is an interesting note that Park asked the Association in 1849 to consider a plan of introducing uniform standard books for elementary and collegiate education, a

[1] The gift of Miss Mary Park, daughter of Roswell C. Park, included: *Exposition of the objects and views of the Associate Society of West Point.* New York: J. & J. Harper, 1830; *J. Amer. Ass. Prom. Sci., Lit., Arts,* 1831, **1**, Nos. 1–4 (2nd ed., rev. by the Central Committee); printed circular letter signed by Roswell Park, Newport, Rhode Island, 10 April 1832, 4 pp.

[2] See *Proc. Amer. Ass. Adv. Sci.,* September 1848, pp. 144–156.

portion of the objectives of the earlier society.[3] Henry Lane Kendrick, of the West Point class of 1835, and Jacob Whitman Bailey, of the class of 1832, both of whom served as professors at the Military Academy, were also charter members. The latter became a regular contributor to the *Proceedings* of the Association after 1849. Alexander D. Bache, of the class of 1825, was a charter member and president for 1850. Other charter members of the Association who were also graduates of the Military Academy were J. J. Abert, James D. Graham, H. W. Halleck, Daniel Ruggles, J. G. Totten, and Charles Whittlesey.

Without question The Associate Society of West Point of the American Association for the Promotion of Science, Literature, and the Arts was a direct forerunner of the American Association for the Advancement of Science.

[3] See *Proc. Amer. Ass. Adv. Sci.*, August 1849, p. 65.

Science Legislation

S. 1850 in the House

Howard A. Meyerhoff, Executive Secretary, AAAS

The vote in the Senate on S. 1850 was conclusive and gratifying, but the division of 48 to 18 cut too close to party lines to be entirely satisfactory to scientists. The deletion of the provision creating a Division of Social Sciences in the National Science Foundation was a major casualty, but it was the only one the bill suffered. Perhaps a Division of Social Sciences will be restored in House action, but this is less a problem now than to persuade the House that action should be taken on any National Science Foundation bill, in these last, crowded days of the 79th Congress.

Heretofore, scientists have had little professional interest in, and little occasion to learn, the established modes of Congressional procedure, *but intimate knowledge of procedure is critical now.*

The House has before it two bills of its own: (1) H.R. 6448, the Mills Bill, which is the exact duplicate of the Senate's discarded Magnuson Bill, S. 1285; and (2) H.R. 6672, the Celler Bill, which is identical with S. 1850, unamended. In addition, it now has (3) the Senate bill S. 1850, as amended and passed. All these bills have been referred to the Subcommittee on Public Health in the Committee on Interstate and Foreign Commerce. Any one of these bills must first be reported favorably by the Subcommittee on Public Health to the Committee on Interstate and Foreign Commerce, which, in turn, must report it favorably to the House, where it must be placed upon the calendar by the Committee on Rules, before it can be debated on the floor.

Only the conviction that the legislation is both sound and urgent will move these several committees to act with the dispatch which is essential. *And it is up to the scientists to give the members of these committees that conviction.*

This is, again, a time for action! No individual scientist can allow summer teaching, research, or relaxation to interfere with his duty to let his congressman know his position on these bills. It makes no difference if he has written sometime before this. He must write again, or better, telegraph, or even use the telephone, but in some manner, he must communicate with the following key people in the House!

(1) ***Members of the Subcommittee on Health,*** **who include: J. Percy Priest, *Chairman,* Tennessee; Vito Marcantonio, New York; Clarence J. Brown, Ohio; Alfred L. Bulwinkle, North Carolina; Virgil Chapman, Kentucky; Wilson D. Gillette, Pennsylvania; Thomas D. Winter, Kansas.**

(2) ***Members of the Committee on Interstate and Foreign Commerce,*** **who include, in addition to the Representatives of the Subcommittee listed above: Clarence F. Lea, *Chairman,* California; Robert Crosser, Ohio; Lyle H. Boren, Oklahoma; Lindley Beckworth, Texas; Oren Harris, Arkansas; George D. Sadowski, Michigan; Richard F. Harless, Arizona; John W. Murphy, Pennsylvania; Edward A. Kelley, Illinois; Luther Patrick, Alabama; John B. Sullivan, Missouri; Dwight L. Rogers, Florida; Benjamin J. Rabin, New York; Charles A. Wolverton, New Jersey; Pehr G. Holmes, Massachusetts; B. Carroll Reece, Tennessee; Charles A. Halleck, Indiana; Carl Hinshaw, California; Evan Howell, Illinois; Leonard W. Hall, New York; Joseph P. O'Hara, Minnesota.**

It is not enough merely to ask for action; you must name the bill you favor.

AAAS Council voted 233 to 10 to support S. 1850, which incorporates carefully evolved compromises on the controversial issues. These issues were re-introduced into H.R. 6448 to the disadvantage of the larger body of scientists.

It should also be remembered that, if the House passes a bill other than the amended Senate bill, there will be three more hurdles for the National Science Foundation to take before Congress adjourns: the bills must then go to conference; the final bill adopted in conference must be approved in the Senate and in the House.

Failure to clear any one of these committees, or the House, means the death of the National Science Foundation in this session of Congress!

Technical Papers

Spinal Cord Circulation in Poliomyelitis

NORMAN NELSON
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A promising phase of research in poliomyelitis, so obvious as to have been completely overlooked, should no longer be neglected. Overwhelming evidence exists that disturbed circulation of the spinal cord is one factor in the production of paralysis in poliomyelitis; yet no real attempt has been made to alter the outcome of poliomyelitis by altering the circulation of the cord.

Years ago W. Lloyd Aycock (*1*) described edema of the spinal cord as one of the major pathologic findings in poliomyelitis and suggested that the large eventual recovery from the paralysis of the acute state of poliomyelitis might be due in part to subsidence of this edema. Yet what does edema mean? Every physician knows that edema, whether local or generalized, means some sort of circulatory disturbance. The perivascular infiltration seen in sections of the cord in poliomyelitis also points to circulatory involvement.

That the circulation of the body is intimately tied in with the sympathetic nervous system has been known for many years. In acute poliomyelitis localized areas of sweating, indicating involvement of the sympathetics, may be seen.

It is a well-established fact that postpoliomyelitis paralytics frequently have markedly disturbed circulation in the involved extremity. In fact, the majority of these paralyzed extremities are cold and extremely susceptible to temperature changes. It has also been suggested that the lack of growth and relative shortening that sometimes results in extremities paralyzed from poliomyelitis may be due to this circulatory inadequacy.

DISTRIBUTION OF PARALYSIS

The paralysis of poliomyelitis, while varying from individual to individual, shows a remarkable constancy when one group of cases is compared with another. Legs are more frequently involved than arms; arms more than trunks, etc. In fact, certain muscles of the leg (*i.e.* the anterior tibials and peroneals) and certain muscles of the arm (*i.e.* the deltoid) show a special predilection to become paralyzed in poliomyelitis. For years it has been explained by the superficial suggestion that the anterior horn cells of the different parts of the cord vary in their susceptibility. It seems more reasonable that the anterior horn cells of the cord vary in their environment (for instance, circulation) rather than in their intrinsic nature.

A consistently characteristic distribution of paralysis in poliomyelitis that also demands explanation and points even more to circulation as a factor in determining the ultimate residual paralysis is the significant predominance of paralysis in the left arm over the right as contrasted to equal paralysis in both legs. In a study of the distribution of paralysis in 1,200 poliomyelitis patients at the Harvard Infantile Paralysis Clinic (1925–41) (*3*), the writer found a statistically significant preponderance of paralysis in the left arm. This difference was greatest with completely "gone" muscles (**Fig. 1**).

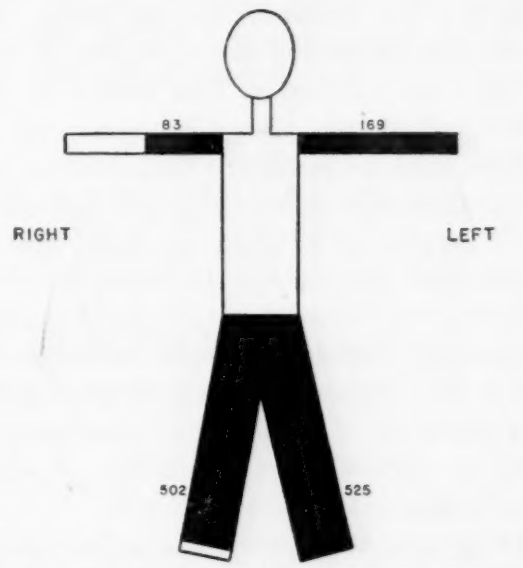

FIG. 1. Number of "gone" muscles, left and right, in 1,200 poliomyelitis paralytics (extremities only).

Robert W. Lovett, of Harvard University, dean of American orthopedists, in 1915 (*2*) called attention to this predominance of paralysis in left arm over right and pointed out that, whereas under the age of 5 years left and right arms were equally involved, from 6 to 38 years of age (when right-handedness is better developed) there were three left arms involved for every right arm. Ivan Wickman (*4*) in 1913 described this same preponderance of paralysis in the left arm over the right.

Further careful analysis of the distribution of paralysis in poliomyelitis brings out these facts: Although better than 95 per cent of all cases of poliomyelitis have at least one extremity which escapes paralysis, *"when an extremity is involved at all, more than two thirds of its muscles on the average show demonstrable paralysis* three weeks to three months after onset" (*3*). Why should the muscles in one ex-

tremity be so completely involved when other entire extremities in the same individual have completely escaped? "It would seem that all of the anterior horn cells of an extremity are probably affected together, with the resulting paralysis depending on intrinsic factors, such as blood supply, pressure from edema, or activity" (*3*).

Localization of Paralysis

There have been many peculiar individual occurrences of localization of paralysis in poliomyelitis, each of which might be well explained as a coincidence, but all of which, when accumulated, can be explained by the common factor of alteration of circulation. A few examples follow:

In the *Journal of the American Medical Association* for 8 September 1945, Brown, Francis, and Pearson describe a peculiarly significant occurrence of poliomyelitis in a child 19 days after the virus of poliomyelitis was first isolated from his stools. Although this child was harboring the virus for 19 days (the usual incubation period is 7–14 days), he remained well until immediately after a canoe race in which his arms were used as paddles. That evening he developed paralysis only in his arms. To deny the significance of association between the canoe race and the development of paralysis in the arms, one would have to postulate two unusual simultaneous coincidences: (1) the onset of paralysis immediately after the canoe race in a child infected at least 19 days previously; (2) the limitation of paralysis to the extremities used, the arms (a relatively rare distribution of paralysis in poliomyelitis).

A recent case of poliomyelitis in Los Angeles developed his only paralysis in a leg which four months previously had had a compound fracture and in which a plate had been inserted to hold the femur. Obviously, such an accident and surgical procedure would alter the circulation of that extremity.

The writer in his personal experience has seen three individuals develop poliomyelitis within 14 days of an immunization procedure, with its usual subsequent localized edema and induration, residual paralysis remaining only in the extremity in which the inoculation occurred.

The peculiar localizing effects of definitely established trauma or overactivity on the paralysis in such cases force one to consider seriously the common factor of circulatory disturbance as a determining factor in the development of paralysis.

Recent attempts to explain the action of Sister Kenny's therapy have revealed that interference with the circulation of the cord of the dog causes damage to the internuncial cells similar to that seen in poliomyelitis.

Alteration of Spinal Cord Circulation in Poliomyelitis

We are attempting in Los Angeles to alter circulation of the spinal cord in animals and humans with poliomyelitis, with a view toward altering the course of the disease. The paravertebral block is one method being tried.

A successful paravertebral block will, of course, increase the circulation of an extremity. That the circulation of that part of the cord supplying that extremity is increased has not as yet been shown. We are, however, proceeding for the time being on the inference that the extremity and that part of the spinal cord supplying the extremity operate as a single physiological unit, and anything which alters the circulation of the extremity will also alter the circulation of the cord involved.

It should be clearly understood that this is merely a preliminary report of work going on, made with the hope that it will stimulate others to investigate this field. Our results are too inadequate to warrant any conclusion that paravertebral block is a treatment for poliomyelitis. We do feel, however, that similar studies to determine the effect of alteration of circulation on residual paralysis and muscle spasm are indicated by much evidence.

Conclusion

A careful analysis of the distribution of paralysis in 1,200 cases of poliomyelitis and localizing effects of trauma or strain points toward alteration of the circulation of the spinal cord as being a determining factor. The paravertebral block is being studied as one possible means of altering that circulation.

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The Effect of Thiouracil and Thyroactive Substances on Mouse Susceptibility to Poliomyelitis Virus[1]

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An investigation of the effect of environmental temperature on the resistance of Swiss white mice to poliomyelitis virus (*1*) suggested that the marked tolerance of these animals to the infectious agent when acclimated to low temperatures, might be due to an altered metabolic rate of their tissues, inter

[1] The writer wishes to acknowledge the technical assistance of H. R. Neal in certain phases of this investigation.

fering with the ability of the virus to establish itself. It is known that thyroxin secretion is greater upon exposure to cold and that the metabolic rate is thereby increased. Hence, a series of investigations was begun on three groups of five-week-old mice inoculated intracerebrally with 0.05 ml. of a 3-per cent suspension of infected brain-cord suspension and held at room temperature (22° C.). One group was given a daily dose of 0.5 mg. of thiouracil by mouth, a second group received 0.5 mg. of thyroid extract by the same method of administration, and the third group served as controls. The amounts of thiouracil, a recognized basal metabolism depressant, and thyroid extract fed to the animals were arbitrarily employed after a limited series of experiments to determine toxic doses. There was no visible indication that the amounts used were toxic.

During the course of this experiment C. W. Turner, of the University of Missouri, suggested and supplied a thyroactive iodocasein prepared by the method of Reineke and Turner (*3*) and referred to by Koger and Turner (*2*) as thyroprotein. A second set of three groups of five-week-old mice was infected with virus. One group was given 0.5 mg. of thiouracil and another group, 0.5 mg. of thyroprotein daily by mouth. The third group served as controls.

The results obtained to date have been quite encouraging. Infected five-week-old mice treated with thiouracil have invariably shown symptoms of paralysis and have succumbed earlier than the controls, whereas those given thyroid extract or thyroprotein have undergone incubation periods much longer than those of the controls (Table 1). The lengthy incubation periods attained with thyroprotein treatment imply that it is much more effective than thyroid extract. However, this may be due to failure at the present time to employ these two agents in doses containing identical amounts of thyroactive substance.

TABLE 1

THE EFFECT OF THIOURACIL AND THYROACTIVE SUBSTANCES ON SUSCEPTIBILITY OF SWISS WHITE MICE TO POLIOMYELITIS VIRUS

Number of mice in each group	Type of treatment after inoculation	Incubation time (days) required to effect 50 per cent mortality in each group
20	0.5 mg. thiouracil daily	5
8	0.5 mg. thyroid extract daily	11
36	0.5 mg. thyroprotein daily	14
20	Nontreated controls	7

Attempts to measure the effect of thiouracil, thyroid extract and thyroprotein on metabolism of the mice, employing techniques adapted to small animals, have not proved highly successful, but there is an indication that the thyroactive substances increase the metabolic rate considerably. Hence, an earlier suggestion (*1*) that the marked decrease in the incidence of poliomyelitis with the onset of cooler weather may be due in part to a change in the metabolism of the host seems to have gained support.

The effect of altered metabolism on resistance to poliomyelitis virus needs careful study. Normally, four- and five-week-old mice tend to be the most susceptible to the virus. Experiments in this laboratory have shown that thyroactive substances create longer incubation periods in mice of these ages than in older animals. Possibly there is a critical metabolism range for virus growth that can be exceeded quite readily by use of thyroid stimulants in four- and five-week-old mice, whereas older animals may have their lower normal metabolic rate elevated to the critical range upon thyroid stimulation and thus become more susceptible than they normally are. When more is known about tissue metabolism and the safety with which thyroactive substances can be administered, it is possible that these agents may have prophylactic value for certain age groups during epidemic periods of poliomyelitis.

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The Failure of Poliomyelitis Virus to Grow in Certain Protozoa of Sewage[1]

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C. Kling, who is well known for his studies of poliomyelitis in Sweden during the past 35 years, has estimated from tests made in 1939 that the amount of poliomyelitis virus in the sewage from a section of Stockholm having a population of 100,000 could reasonably be accounted for only if 100 per cent of the people were excretors of the virus or if the virus grew in sewage. He has rejected the former possibility (*1*) and has suggested that the virus probably grows in some microorganism of sewage, the most likely one being, in his opinion, protozoa of the genus Bodo.

Unaware of Kling's observations, we were also led to speculate on the possibility that poliomyelitis virus might grow in some microorganism of sewage, and during the past several years we have investigated this question.

[1] Aided by grants from the National Foundation for Infantile Paralysis, Inc., and the Graduate School of the University of Minnesota.

Attention was first directed to aquatic protozoa in general, and simple tests for the growth of poliomyelitis virus in the protozoa and other microorganisms occurring in lake water, pond water, river water, and sewage were carried on during the poliomyelitis season (August and September) in 1944. Samples of water were collected in 150-ml. amounts and kept in finger bowls or Erlenmeyer flasks at 70° F., the approximate temperature of the waters when collected. Protozoa were found in the usual abundance, with some increase of certain varieties during a one-week period of incubation. A pool of 12 strains[2] of poliomyelitis virus was prepared as a 10-per cent suspension of monkey spinal cord. Fifteen ml. of this pool was added to 135-ml. specimens of freshly collected water, giving an initial dilution of 1:100. Seven days later 15-ml. samples were transferred to dishes containing 135 ml. of freshly collected waters from the same sources. Serial weekly transfers involving 10-fold dilutions were carried out to a final dilution of 1:100,000. One week after the last transfer, specimens from each dish were treated with ether and injected into a total of eight monkeys. No evidence of poliomyelitis developed in the inoculated animals. Parallel tests with two strains of Theiler's virus (New Jersey I and GD VII) and with Armstrong's strain of mouse-adapted poliomyelitis virus also gave negative results.

In subsequent work, cultures of specific protozoa have been employed, and only those kinds of protozoa that occur commonly in sewage have been studied. Surveys of the protozoa of the Minneapolis and St. Paul sewerage system during the summer and fall of two successive years have shown clearly that the genus Bodo includes the protozoa most regularly present in all parts of the system tested and that one species or another of the genus is usually the most abundant protozoan present. Frequently the Bodos outnumber all other protozoa combined. Numerous other genera are represented, but only a relatively few occur with sufficient frequency or in sufficient numbers as conceivably to be of importance as hosts of the poliomyelitis virus.

In the past year six strains of Bodo were isolated from different samples of sewage and tested for their capacity to support the growth of poliomyelitis virus. At the same time one strain of Monas, one of Oikomonas, and three crude cultures containing significant populations of Tetrahymena, Uronema, Monas, and Pleuromonas, and other protozoa in smaller numbers, were similarly tested.

Six strains of poliomyelitis virus were used, including one strain capable of growing in rodents, "MEF" (*2*); one strain represented by infective human fecal material, kindly supplied by John R. Paul; one highly virulent laboratory strain; and three strains that had been passed only a few times through monkeys since original isolation from man.

The procedure employed was to cultivate the protozoa in flasks in 10 ml. of fluid wheat extract on the surface of 25 ml. of agar containing minerals and organic nutrients. Cultures were incubated in dim light at 70° F. Following each transfer, protozoan populations increased during a period of several days to a maximum of from 100,000 to 50,000,000 or more in each milliliter of culture. In our observations of raw sewage the total number of protozoa of all kinds has usually been from 20 to 100/ml.

Virus was added initially to the protozoan cultures as 0.25 ml. of a 10-per cent suspension of infected spinal cords, giving an initial dilution of 1:400. At intervals of 5 and 14 days (two experiments) subcultures were made by transferring 0.1 ml. to a freshly prepared flask. In this manner a 1:100 dilution of virus was accomplished with each transfer, so that after two subcultures the original virus was diluted to 1:4,000,000. In a control titration, none of the six strains of virus had infected monkeys in a dilution of 1:2,000,000. Samples of fluid taken from the third set of cultures (second subcultures) were treated with ether and by low-speed centrifugation to remove bacteria, and were tested for poliomyelitis virus by intracerebral injection of monkeys.

It was believed that no method of concentrating virus need be employed because the populations of protozoa in the cultures so greatly exceeded those in sewage that any growth of virus to the extent that would be significant in sewage should be easily detected.

Three monkeys were injected with material pooled as to protozoan culture in the first test (subcultured at 5-day intervals). In the subsequent tests, pools of all cultures of "MEF" virus, "Stool" virus, and "Virulent" virus were prepared separately and injected into different monkeys. Results were uniformly negative. Protozoan cultures to which the "MEF" "Stool," and "Virulent" viruses had been added were carried through one additional transfer in the 14-day series and were pooled and concentrated approximately 40-fold by centrifugation at 40,000 r.p.m. for one hour. Again three monkeys were injected with negative results.

Bacteria present in the protozoan cultures represent a complicating feature that would be difficult to avoid. However, bacteria are abundantly present in sewage and we have found that the GD VII strain of Theiler's virus (which resembles poliomyelitis virus in stability

[2] The MV, Hartford, and McKay strains plus 9 others, most of which had been passed only a few times in monkeys since originally isolated.

survives relatively well in sewage kept at 70° F., in spite of very considerable increases in bacteria during storage.

It is concluded that in our experiments the naturally occurring microorganisms in water from a pond, a lake, and a river failed to yield significant increase in several strains of poliomyelitis virus, and that six strains of Bodo, two of Monas, and one each of Pleuromonas, Oikomonas, Tetrahymena, and Uronema, derived from sewage, failed to support the growth of poliomyelitis virus to an extent that would be significant with reference to the finding of the virus in sewage.

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Influence of Anesthesia on Experimental Western Equine Encephalomyelitis[1]

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Past attempts at therapy in neurotropic virus diseases have been largely unsuccessful. The results have been essentially negative because once the symptoms of a virus disease have become evident, the virus is already well established within the host cell. Therapeutic agents are therefore unable to gain access to the virus, with the result that treatment is of little value. Nevertheless, there have been suggestive positive results with both serotherapy and chemotherapy in this group of diseases. Zichis and Shaughnessy (*14*) reported successful treatment of experimental western equine encephalomyelitis infections using hyperimmune rabbit serum, but their observations have not been fully confirmed (*8*). Wherever positive results have been obtained, early administration of potent antiserum has been found to be essential. Successful chemotherapy has been limited to the so-called lymphogranuloma venereum-psittacosis group (*10*), which, however, some workers place intermediate between true filtrable viruses and rickettsiae. Generally, in true virus diseases, chemotherapy has been ineffective (*5*).

The ideal therapeutic agent for use in the treatment of neurotropic virus diseases would bring about a reversible change in the metabolism of the host cell sufficient in degree and duration to destroy the virus without causing permanent injury to the host cell, and must have predilection for cells of the central nervous system. General anesthetics seem to fall within this category. Our interest in the use of anesthetics in neurotropic virus diseases was further prompted by a number of reports on the influence of anesthesia on the course of several other diseases affecting the central nervous system. Bronfenbrenner and Weiss (*1*) noted that anesthetics, alone and in combination with specific antitoxin, decreased mortality in experimental botulism. Similarly, avertin (or tribromethanol) has been used to alleviate muscular spasms in tetanus (*4, 7*).

The *in vitro* effect of ether on viruses has been observed by several workers. When used in relatively high concentrations, this anesthetic is an effective bactericidal agent and can be used *in vitro* to destroy bacterial contaminants in tissues infected with poliomyelitis (*6*), rabies (*12*), and measles (*9*) without affecting the virus. The method, however, is not applicable in removing contaminants from tissues infected with St. Louis encephalitis or equine encephalomyelitis viruses (*2, 3*).

In the present studies a strain of western equine encephalomyelitis virus, obtained from W. McD. Hammon, was used. The virus was maintained by intracerebral injection of Swiss mice. A 20-per cent suspension of infected mouse brain tissue was prepared using 10 per cent sheep serum-broth as diluent. The supernate, removed after centrifugation, was dispensed in 0.2-ml. amounts in sterile glass ampules which were then sealed, frozen quickly, and stored in the deep-freeze cabinet. Under these conditions the titer of virus remains constant for several months. The quantity of virus present in the stock suspension was determined by intracerebral inoculation of three- to four-week-old mice, and the 50-per cent end point (LD_{50}) was calculated according to the method of Reed and Muench (*11*).

In the experiment to be described each three- to four-week-old Swiss mouse was inoculated intracerebrally under light ether anesthesia with 0.03 ml. of a $10^{-8.5}$ dilution of stock virus suspension (approximately $3 \times LD_{50}$). In order to avoid errors due to sequence of inoculation, all inoculated mice were placed in one large cage and then separated at random into three groups. Group I served as controls and received no subsequent treatment. Group II received three four-hour periods of diethyl ether anesthesia during the first 36 hours after intracerebral inoculation, while Group III received two four-hour periods of ether anesthesia beginning at the time the animals first showed symptoms of encephalitis. The open method was used for the administration of the anesthetic. All animals were observed for central nervous system symptoms and death from encephalitis during

[1] The study of which this is a preliminary report was aided by a grant from the National Foundation for Infantile Paralysis, Inc.

a period of 10 days. The results are summarized in Table 1. The effect of ether anesthesia on the course of the experimental infection became evident early in the experiment. By the third day, 51.3 per cent of the controls had died, and only 29.1 per cent and 26.7 per cent, respectively, of the anesthetized animals had died. Thus, in addition to the increase in total survivors with ether anesthesia, there is also a delaying effect on the progress of the disease. To determine whether or not the data were statistically valid, the p values were calculated. The differences in the mortality rates were highly significant when the control group of animals was compared with each of the treated groups.

These studies are being extended to include experiments with other general anesthetics, which possibly may be more effective than diethyl ether in the treatment of experimental neurotropic virus infections. Several neurotropic viruses are under investigation. A preliminary study concerning the effect of combined ether anesthesia and antiserum on western equine encephalomyelitis in mice has been reported elsewhere (*13*).

TABLE 1

INFLUENCE OF ETHER ANESTHESIA ON THE COURSE OF EQUINE ENCEPHALOMYELITIS (WESTERN) IN SWISS MICE

Group	Virus inoculum	Number of mice*	Per cent of animals dying from encephalitis during successive days after virus injection										Mice surviving†	
			1	2	3	4	5	6	7	8	9	10	Per cent	p‡
I (Controls)	$.03 \times 10^{-8.5}$ (3 LD_{50})	39	0	5.1	46.2 (51.3)§	36.0 (87.3)	0 (87.3)	5.1 (92.4)	0	0	0	0	7.6	
II Anesthetized‖ (immediately)	same	31	0	6.5	22.6 (29.1)	25.8 (54.9)	3.2 (58.1)	0	0	0	0	0	42.0	.001
III Anesthetized¶ (Delayed)	same	30	0	3.3	23.4 (26.7)	30.0 (56.7)	0 (56.7)	3.3 (60.0)	0	0	0	0	40.0	.002

* Animals which died from trauma or ether are not included.
† Survived observation period of 10 days.
‡ Values obtained by reference to appropriate tables in Pearl's *Medical biometry and statistics.* Philadelphia: W. B. Saunders, 1930.
§ Figures in parentheses indicate cumulative per cent deaths.
‖ Three four-hour periods of anesthesia administered beginning immediately after virus injection.
¶ Three four-hour periods of anesthesia administered beginning approximately 40 hours after virus injection.

These studies are being extended to include experiments with other general anesthetics, which possibly may be more effective than diethyl ether in the treatment of experimental neurotropic virus infections. Several neurotropic viruses are under investigation. A preliminary study concerning the effect of combined ether anesthesia and antiserum on western equine encephalomyelitis in mice has been reported elsewhere (*13*).

Summary. Anesthesia, by ether, is effective in the treatment of western equine encephalomyelitis in mice. Of mice treated with deep ether anesthesia soon after the intracerebral injection of western equine virus, only 58 per cent developed the disease as compared with 92.4 per cent of control animals. When anesthesia was delayed the approximate length of the incubation period, 60 per cent of the animals developed the disease as compared with 92.4 per cent of the controls. In addition, ether anesthesia delays the development of central nervous system symptoms not only when administered soon after the injection of the virus but also when administered after the disease has progressed far enough to cause objective signs of encephalitis.

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News and Notes

About People

Edward B. Stephenson, Office of Research and Inventions, Navy Department, has been presented the Meritorious Civilian Service Award for his outstanding service to the Navy within the Sound Division.

E. Newton Harvey, Department of Biology, Princeton University, has returned from Brazil, where he gave a series of lectures on biophysics, during April and May, at the Instituto Biofisico of the Medical School of the University of Brazil, Rio de Janeiro. Dr. Harvey spoke on bioluminescence, the cell surface, decompression sickness, the nerve impulse, brain waves, and the mechanism of wounding.

Saul B. Arenson, professor of inorganic chemistry at the University of Cincinnati, has resigned his position and will move to California. For the past 20 years he has been secretary-treasurer of the University of Cincinnati Chapter of Sigma Xi.

Karl Spencer Lashley, of the Yerkes Laboratories of Primate Biology, Orange Park, Florida, has been awarded a Daniel Giraud Elliot medal by the National Academy of Sciences for his paper, "Studies of cerebral function in learning," published in the *Journal of Comparative Neurology.*

William Reiner-Deutsch has joined the staff of Industrial Testing Laboratories, New York City, as microbiologist. Dr. Reiner-Deutsch has recently been released from active duty as a lieutenant colonel in the Sanitary Corps after having served over three and a half years with general hospitals here and overseas.

Thomas P. May, Office of Research and Inventions, Navy Department, has received the Meritorious Civilian Service Award, in part for his contributions in the development of rain-repellent and defogging compounds for airplane cowling and optical instruments.

John F. Lontz has rejoined the Experimental Station staff of E. I. du Pont de Nemours & Company, Wilmington, Delaware, as research chemist. Dr. Lontz has been released from active duty after having served as a lieutenant colonel in the Chemical Warfare Service in Europe.

B. S. Schweigert, Department of Biochemistry, University of Wisconsin, has been appointed nutritionist of the Texas Agricultural Experiment Station. The appointment became effective 1 June.

Thomas Francis, Jr., of the University of Michigan, discussed "The Conquest of Influenza" in the fourth annual A. C. Helmholz lectureship at the University of Wisconsin Medical School on 20 June. This lectureship was endowed in 1941 by the four children of Mr. and Mrs. A. C. Helmholz of Milwaukee. Previous lecturers have been Anton J. Carlson, Harry Goldblatt, and T. Duckett Jones.

Washington Buño, professor of histology and embryology in the Faculty of Medicine of the University of Montevideo, has been appointed to a Guggenheim fellowship and is now in Baltimore for work in the Department of Embryology, Carnegie Institution of Washington.

Frank F. Grout has resigned as director of the Minnesota Geological Survey to devote full time to teaching and completion of field and research problems. George M. Schwartz has been appointed to succeed Prof. Grout.

Howard Canning Taylor, Jr., has been appointed professor of obstetrics and gynecology in the College of Physicians and Surgeons and director of the Obstetrical and Gynecology Service of the Presbyterian Hospital, New York City. Dr. Taylor succeeds Benjamin P. Watson, who remains in private practice and continues his affiliation with the Sloane Hospital of the Medical Center after retiring on 1 July.

Clyde E. Williams, director of Battelle Memorial Institute, Columbus, Ohio, was awarded the Doctor of Science degree from the University of Utah at its 77th annual commencement exercises on 4 June. Mr. Williams was in charge of all the Government's metallurgical research during the war.

James Lewis Howe, professor emeritus of chemistry, received the Doctor of Science degree from Washington and Lee University on 1 June.

Capt. Albert Paul Krueger, MC(S), USNR, Commanding Officer, Naval Medical Research Unit No. 1 (Berkeley, California), will return to the University of California as chairman of the Department of Bacteriology after five and a half years of active duty in the Navy.

Hans Popper has returned from active duty in the Army Medical Corps to his former position as research director of the Hektoen Institute for Medical Research, Chicago. He has also resumed his duties as director of the Department of Pathology, Cook County Hospital.

Leo L. Beranek, John Simon Guggenheim fellow jointly at the Massachusetts Institute of Technology and Harvard University, was awarded the degree of Doctor of Science on 3 June 1946 by Cornell College, Iowa, where he was graduated in 1936.

Samuel M. Moffett, assistant professor of chemistry, Ohio Wesleyan University, has been named to a similar capacity at Park College, Parkville, Missouri, effective in September.

R. V. Boucher, of the Department of Agricultural and Biological Chemistry, Pennsylvania State College, has accepted the chairmanship of the Committee on Feed Composition of the National Research Council.

Walter J. Breckenridge has been appointed director of the Minnesota Museum of Natural History to succeed Thomas S. Roberts. Dr. Breckenridge has been made associate professor at the University of Minnesota.

Harry Landis, formerly with the Schenley Laboratories, Lawrenceburg, Indiana, has joined the staff of the Warner Institute for Therapeutic Research as a bacteriologist in the Department of Pharmacology and Chemotherapy.

Frank Ralph Kille will become dean of Carleton College, Northfield, Minnesota, next year. Dr. Kille will continue as professor of zoology.

Philip A. Munz will occupy the position of botanist at Rancho Santa Ana Botanic Garden, Anaheim, California, after 1 August 1946.

Thorne M. Carpenter received the degree of Doctor of Science on 10 June from the Massachusetts State College.

Robert M. Muir has been appointed instructor in botany at Pomona College, Claremont, California, beginning with the year 1946–47. He is completing the work for the degree of Doctor of Philosophy in plant physiology at the University of Michigan, and has just returned from the China-Burma-India war theater, where he has served as a meteorologist in the U. S. Army Air Force.

David S. Saxon joined the Research Staff of Philips Laboratories, Inc., on 1 April, as an associate physicist and is in charge of the Section on Theoretical Physics. At present he is working on the theory of the stability of high-energy particle accelerators such as the synchrotron and frequency modulated cyclotron.

P. Maheshwari, chairman of the Department of Botany at the University of Dacca, India, spoke to the seminar group of the Department of Botany, Northwestern University, 4 June, on "Plant Research in India."

Karl Ver Steeg, College of Wooster, received the degree of Doctor of Science at the 93rd annual commencement exercises at Central College, Pella, Iowa, on 20 May. Dr. Ver Steeg was graduated from Central College in 1914 and has been head of the Department of Geology and Geography at the College of Wooster since 1923.

Kendall Emerson, Jr., formerly associated with the Rockefeller Institute and reecntly returned from service with the U. S. Naval Medical Research Unit No. 2 (Guam), has been appointed associate in medicine at the Harvard Medical School and senior associate in medicine at the Peter Bent Brigham Hospital. In addition to clinical teaching and research, Dr. Emerson will be in charge of the Chemical Laboratory and the Metabolic Division of the Hospital.

Edward M. Brooks, instructor in meteorology at Massachusetts Institute of Technology, has been appointed assistant professor of geophysics in the Institute of Geophysical Technology, Saint Louis University.

Harlan L. Tuthill, formerly with Rohm and Haas, has recently joined the research staff of Smith, Kline and French Laboratories, Philadelphia, as head of the Department of Physical Chemistry.

Albert M. Reese, since 1907 professor of zoology at West Virginia University, has been retired from active service and made professor emeritus. At a testimonial meeting held in his honor on 26 May numerous former students and associates presented him with a volume of letters addressed to him for the occasion and a fund designated as the Albert Reese, Jr., Scholarship Fund for the education of his 13-year-old son.

Alfred R. Loeblich, Jr. assumed his duties as associate curator in the Division of Invertebrate Paleontology and Paleobotany, Department of Geology, U. S. National Museum, on 31 May. Dr. Loeblich's special field at the National Museum is Lower Paleozoic stratigraphy, with emphasis on Ordovician and Silurian strata and faunas. He will also assist in caring for fossil sponges, coelenterates, and bryozoans.

Harvey Fletcher, director of physical research, Bell Telephone Laboratories, Murray Hill, New Jersey, gave the 15th Joseph Henry Lecture of the Philosophical Society of Washington on 25 May. Dr. Fletcher spoke on "The Pitch, Loudness, and Quality of Musical Tones."

Announcements

The Committee on Line Spectra, National Research Council, met as guests of the National Bureau of Standards in Washington, D. C., on 23 May at the invitation of E. U. Condon. Chairman H. N. Russell, Princeton University, called the Committee together to discuss in detail the compilation of a new list of atomic energy levels. This work is now being done in the Spectroscopy Section, National Bureau of Standards.

It was decided to send a questionnaire, as to the form to be adopted, to a number of workers in different fields who would find such a book useful. Those now working on spectrum analysis are invited to report their results so that unpublished material can be included.

Those attending the meeting were: J. C. Boyce, E. U. Condon, G. R. Harrison, C. J. Humphreys, C. C. Kiess, J. E. Mack, W. F. Meggers, H. N. Russell, A. G. Shenstone, and C. M. Sitterly. Two other members, I. S. Bowen and R. E. Sawyer, were unable to be present.

"Can Science Prevent War?" an address expressing the scientist's viewpoint on the prospects for world peace, was delivered by Philip A. Leighton in Claremont, California, on 1 June before a meeting of Pomona College alumni. Dr. Leighton, who is executive head of the Department of Chemistry, Stanford University, and acting dean of the School of Physical Sciences, said that while science alone could not prevent war, it could eliminate many of the basic causes of war. Citing one historical basis of conflict facing the world, he declared: "Give science the same money, the same man power now being spent making atom bombs, and I predict science can eradicate the current famine."

Dr. Leighton then outlined three points upon which he believed peace might be based. (1) Science could be applied to solve the fundamental problems underlying open conflicts. (2) The individual, scientist or layman, could do much to keep the world aware of the full meaning of another global conflict. (3) The existing international brotherhood of scientists, putting human progress above personal or political considerations, could offer a working example for extension of the same principle in political and governmental fields, particularly in some form of world government to replace the sovereign state of today.

The Franz Theodore Stone Laboratory, of the Ohio State University, has received a grant from the American Petroleum Institute for a two-year study of methods for evaluating the effects of industrial wastes on zooplankton. The project will be under the direction of Bertil G. Anderson, West Virginia University, and David C. Chandler, Franz Theodore Stone Laboratory. Two half-time research assistantships at $1,250 per year for two years have been established for graduates with a background in invertebrate zoology and physiology. The men appointed as assistants will be given academic credit for their work on the project. In addition, they may enroll in courses offered at the Laboratory and work toward advanced degrees. Inquiries may be addressed to the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio.

Several scholarships and fellowships are being offered by the Institutum Divi Thomae for 1946–47. Scholarships will defray expenses of tuition and fees, with the fellowships carrying, in addition, a $1,000 stipend. Students qualified for graduate study and research in biochemistry, biology, and experimental medicine are eligible as candidates for the Master's or Doctor's degree. Inquiries should be directed to the Dean, Institutum Divi Thomae, 1842 Madison Road, Cincinnati 6, Ohio.

Geologists may compete for probational appointments leading to permanent status in the Federal service, the Civil Service Commission has announced recently. Persons appointed from the examination will serve in essential positions in such agencies as the Geological Survey (Department of the Interior) and the Bureau of Plant Industry and the Soil Conservation Service (Department of Agriculture). Most of the positions are located in Washington, D. C., and throughout the United States, but some appointments may be made to positions in the territories and possessions of the United States and in foreign countries.

The entrance salaries for geologists appointed from this examination are $2,644.80 (P-1 grade) and $3,397.20 (P-2 grade) per year. The age limit for this examination, except for persons entitled to veteran preference, is 18–62. A written test is required of all applicants. In addition to passing the written test, applicants for the P-1 grade must have successfully completed a full four-year course of study leading to a Bachelor's degree, with at least 30 semester hours study in geology; *or* they must have had 30 semester hours in geology plus appropriate experience to equal a four-year college course. Persons applying for the P-2 grade must meet the requirements for the P-1 grade and, in addition, must have had two years of professional experience in the field of geology. Further details are contained in the examination announcement, which may be obtained from first- or second-class post offices, from any of the Civil Service regional offices, or from the central office of the Civil Service Commission, Washington 25, D. C.

Research Funds for Nutritional Science

The Williams-Waterman Fund for the Combat of Dietary Diseases, since its inception in March 1940, has made grants to 30 institutions in an aggregate approaching $500,000, according to Robert R. Williams, chairman of the Fund. The Fund had its origin in an agreement of October 1935 whereby the inventors of certain processes for the production of vitamin B_1 and its intermediates assigned their present and prospective inventions in this field to Research Corporation, New York City (see *Science*, 5 July 1946, p. 33). The agreement provided for the management of the inventions in the public interest and the devotion of the Corporation's net income from them to the support of research and like objects. Specifically, 50 per cent of the net returns flows into this special fund designated for the combat of dietary diseases.

The arrangement has proved a fortunate one. Research Corporation, founded in 1912 at the instance of Frederick G. Cottrell, was designed essentially for just such a purpose, and its policy in the management of these patents has contributed greatly to the low-cost availability of thiamine for therapeutic and food uses. Food uses took on a greatly added importance in the United States through the now nearly universal process of enrichment of white bread and flour. This process was inaugurated under the leadership of the National Research Council in May 1941 with the support of the principal national organizations of millers and bakers. Neither this event nor the magnitude of the demand for thiamine for therapeutic uses was foreseen at the time of the agreement. Indeed, no complete process of synthesis then existed. Nevertheless, the concept of the original agreement has proven surprisingly sound, and the Fund has attained substantial proportions.

Expenditures under the Fund are supervised by a Committee which at present consists of: J. W. Barker (president of Research Corporation), Howard Coonley, C. G. King, Robert E. Waterman, and R. R. Williams (chairman). Norman Jolliffe, W. H. Sebrell, and H. C. Sherman serve as scientific advisers.

The language of the agreement has been liberally construed to include within the field of the Fund studies in nutrition and metabolism, with the conviction that the advancement of fundamental knowledge in all sciences underlying the use of food is important for the combat of dietary diseases. A major emphasis, however, continues to be placed on practical measures of prophylaxis and therapy of the recognized deficiency diseases. This is in keeping with the origin of the funds which in a sense are a by-product of a long-term study of Oriental beriberi.

Consistent with the policy, extensive support has been given to fostering the enrichment of whole corn meal as a measure against the incidence of pellagra in our South, through the agency of Clemson College and under the leadership of E. J. Lease. A project for the breeding of a high-niacin corn under R. F. Dawson, of Columbia University, is also under way. Similarly, an approach to the problem of beriberi is contemplated. The chairman of the Committee is about to depart for China and the Philippines, where it is hoped projects can be set up at focal points, through local agencies, for the production and distribution of a nutritionally improved form of rice. This practice, so established, should spread gradually to other areas.

An event which has somewhat affected the operation of this Fund was the establishment of The Nutrition Foundation, Inc., in December 1941. This Foundation, supported by contributions from the food and related industries, has made grants totaling over $1,000,000 in support of research in closely kindred fields. The Nutrition Foundation places rather broader emphasis on the function and utilization of food components but less emphasis on the prophylaxis and therapy of specific nutritional diseases. There is, however, a substantial area of overlap in which conflict is avoided by frequent interchange of comment and by membership on the Williams-Waterman Committee of C. G. King, scientific director of The Nutrition Foundation, and the service of R. R. Williams on the Scientific Advisory Committee of the Foundation.

From March 1940, when funds began to accumulate, up to 1 May 1946, grants have been made in the aggregate sum of $436,529.42. Distribution of expenditures for scientific work by years is as follows: 1940, $23,029.52; 1941, $57,707.67; 1942, $74,402.23; 1943, $86,140.00; 1944, $80,715.00; 1945, $82,695.00; and 1946 (to 1 May), $31,840.00.

Institutions which have benefited number 30:

American Bureau for Medical Aid to China, University of Arkansas, University of Arizona, California Institute of Technology, University of California, University of Chicago, Clemson College, Columbia University, University of Cincinnati, Florida State Board of Health, Harvard University, The Johns Hopkins University, Massachusetts Institute of Technology, Memorial Hospital, Mount Sinai Hospital, National Research Council, New York University, Oregon State College, Peter Bent Brigham Hospital, University of Pittsburgh, Post Graduate Medical School, Princeton University, Stanford University, Texas Agricultural and Mechanical College, University of Texas, Tulane University, Union University, University of Wisconsin, Western Reserve University, and Yale University.

The following projects, the titles of which have been abbreviated, are now in progress and serve to illustrate the scope of operations under the Fund:

Niacin deficiency in children: Harry Bakwin; Characterization of *Lactobacillus gayoni* factor: Vernon Cheldelin; Breeding of a high-niacin corn: R. F. Dawson; Clinical investigations of nutritional diseases: Grace Goldsmith; Prenatal nutrition in relation to mentality of young: Ruth Harrell; Pyruvic acid cycle in anoxia: H. E. Himwich; Further studies in oxybiotin: K. Hofman; Hydrolysis of proteins and the amino acid content of vegetables and fruits: Arthur R. Kemmerer; Role of folic acid in cancer: J. C. Keresztesy; Improved staple Southern foods (whole corn enrichment): E. J. Lease; Study of the processes of calcification and ossification: F. C. McLean; Pyrimidine biosynthesis: George W. Beadle; Bacterial flora in relation to intestinal function: V. C. Myers; Work of Food and Nutrition Board: National Research Council; Biological oxidation of pyruvic acid: S. Ochoa; Dietary choline in relation to body stores of choline: P. B. Pearson; Nutritional factors involved in growth and metabolism: Edmond E. Snell; Nutritional Disease Teaching Center, Birmingham: T. D. Spies; Parenteral nutrition: F. J. Stare; Biosynthesis of amino acids: E. L. Tatum; Biochemistry of *Lactobacillus casei* factor: John Randolph Totter; Utility of glutamic acid in epilepsy: H. B. Waelsch; Public health nutrition program of Florida: Walter Wilkins; Nutritional significance of cereal enrichment: Jet C. Winters.

Grants are made only to institutions on application of qualified individuals. The Fund will welcome worthy applications within the scope of its field. Letters should be addressed to: Charles H. Schauer, Secretary of the Committee, 405 Lexington Avenue, New York 17, New York, or to the Chairman, Research Corporation, at the above address. No special application form is required, but letters of application should include a brief but clear description of the project, its potential significance, the plan of attack, and a rough budget of contemplated expenditures. The qualifications of the applicant should also be stated if not available from biographical reference books.

In the Laboratory

Built-in Jacks for Plaster Casts

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Anyone who makes plaster castings knows that it is often difficult to get them out of the plaster molds, especially if they have little "draft." The built-in jack described below makes it possible to lift quite deep castings with great ease and with freedom from damage to casting or mold.

The jack consists of a roundheaded stove bolt measuring about 3/16 × 1 inch, with its nut. The nut is fitted with plasticine cores, as shown in Fig. 1, B, the elongated lower core being a round rod somewhat larger than the bolt. The upper core on the nut, by means of which the assembly is stuck to the model to be reproduced, should be about 3/16 inch thick. When the mold has been poured it will look like Fig. 1, C, in section. The plasticine cores are then cleaned out, and a small piece of sheet metal from a tin can is cut to the size of the nut and dropped on top of it. This may be called the pressure plate. Soft plasticine is then forced in above the pressure plate and shaped with the finger to fit the contours of the mold. The casting is then poured. When this is set, the bolt is inserted and gently turned with a screw driver.

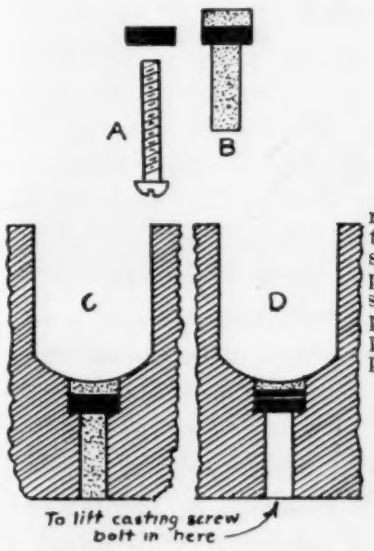

FIG. 1. A—the bolt and nut; B—the nut with plasticine cores; C—the jack assembly cast into the mold; D—plasticine cores removed, pressure plate added above nut, and plasticine filling added above pressure plate; mold ready to pour casting.

This raises the pressure plate and makes the soft plasticine above it ooze out between casting and mold, thus breaking the "seal" between the latter and lifting the casting with ease. The plasticine may be softened by working into it a small amount of vaseline. It should be soft but not sticky. The jack should be located below the estimated center of gravity of the casting, and for large castings several may be used, so disposed that any massive parts will be assisted out of the mold. Where several jacks are used, each must be given a small fraction of a turn in rotation so that the casting rises smoothly as a whole and does not come out at one end first. It is assumed that some one of the usual "parting compounds," such as a mixture of soap and coal oil, will be used on the mold.

An Improved Method for Quantitative Impregnation of Textiles With Germicidal Emulsifiable Oils

THE RESEARCH STAFF[1]

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Oil treatment of floors and bedclothes has been shown to effect significant reductions in concentration of air-borne organisms (*2*) and offers an encouraging approach to the partial control of respiratory infections. Until recently textiles were impregnated with dust-laying oils in a commercial laundry by the addition of an emulsifiable oil to the last water rinse. Subsequent agitation of the laundry rotator produced good contact of the textiles with the emulsion, resulting in absorption of a portion of the oil. This procedure was responsible for considerable waste, since the unabsorbed emulsion was drained off and not reused. The process was not only uneconomical but also technically inadequate for impregnation of a definite concentration of oil per weight of textile material.

Harwood, Powney, and Edwards (*1*) have recently described a technique for application of dust-laying oils to hospital bedclothes. Their method allowed quantitative removal of oil emulsion by the textiles, although different types of emulsions were required for cotton and woolen articles. Loosli and Robertson (*2*), in their recent review on control of dust-borne bacteria, conclude, in part: "Methods for oil-treatment of bedclothes on a large and practical scale have been reported. Much remains to be done in perfecting economical and stable oil-in-water emulsions and techniques of application which can be carried out by unskilled laundry workers."

This laboratory has developed a simple technique for quantitative impregnation of either cotton or woolen textiles with a single stable and inexpensive oil-in-water emulsion.

The procedure for practical application in laundries is as follows:

(1) The textiles are washed in the usual laundry manner, allowing sufficient rinsing for complete removal of soap.

(2) A stable and readily emulsifiable, nonionic, oily material[2] is added to the last water rinse, resulting in a stable oil-in-water emulsion after a few revolutions of the laundry rotator.

(3) During continued agitation a cationic germicidal agent is added, transforming the nonionic emulsion into a bactericidal cationic emulsion. The negatively-charged cotton and woolen textiles quantitatively remove positively-charged oil droplets from the emulsion. After a few minutes of the usual laundry agitation the original milky emulsion loses its opalescence and appears as a clear, watery fluid. This visible change serves as an end point, indicating complete absorption of oil by the textile.

(4) The watery fluid is drained off, and the textiles are finished in the usual laundry manner.

Many thousands of woolen blankets, cotton sheets and pillowcases have been tested for impregnation with a uniform degree of success. It should be pointed out, however, that the laundering process is not a prerequisite for oil impregnation. For example, with colored textiles such as olive-drab blankets laundering need only be practiced when necessary from the standpoint of cleanliness. Analyses of the initial emulsions and the clear drainage fluids have shown complete quantitative exhaustion of the germicide and oil by the textiles. By repeated Soxhlet extraction analyses of the treated textiles it was demonstrated that a known amount of oil can be introduced into either cotton or woolen articles. Detailed procedures for these techniques will be published elsewhere.

The advantage of using a positively-charged emulsion is clearly seen in both the laboratory and commercial laundry. Prolonged manual agitation of cotton or woolen textiles in the original nonionic emulsion produces no visible clearing of the fluid; however, upon addition of the cationic detergent to such an emulsion, a rapid and complete removal of oil droplets ensues. At the present time it is not feasible to employ commercially produced cationic emulsions since considerable difficulty exists in large-scale con-

[1] The opinions advanced in this publication are those of the writers and do not represent the official view of the Navy Department.

[2] The cooperation of the California Research Corporation and the Shell Oil Company in development and preparation of these nonionic compounds is gratefully acknowledged.

pounding of such agents. It should be noted further that the ratio of the emulsifiable oil to the cationic detergent per given weight of textiles is a critical one and that colored textiles require less detergent than white articles. After trial of several cationic agents available, "Roccal," a quaternary ammonium compound (alkyl-3-dimethyl-benzyl-ammonium chloride), appeared to be most suitable.

Blankets treated according to the above procedure and containing 2.5–3.0 per cent of oil by weight of the textile are not oily to the touch, nor are they distinguishable from normally washed controls in appearance or texture. The approximate cost of treatment of a blanket, over and above the usual washing charge, is approximately \$.03–\$.05, while the cost for a sheet is \$.01–\$.015.

Experiments involving shaking or mechanical agitation of blankets impregnated with oil emulsion have shown them to retain over 90 per cent of bacteria and dust when compared to untreated controls. The effective duration of a single treatment is at least six months. Laboratory evidence suggests that the "Roccal" retained in the blankets may be bactericidal to organisms settling and remaining on the textiles.

The oil-treatment process described above offers definite practical advantages in that (a) a single stable emulsifiable preparation is used for impregnation of both cotton and woolen textiles, (b) controlled concentrations of oil can be introduced into the textiles, (c) no waste of oil is involved, (d) the added bactericidal detergent may result in lasting and improved sanitization of treated materials, and (e) an easily determined end point is available to judge the completeness of impregnation.

Subsequent papers to be presented in more detail will deal with: (a) the effective duration of a single impregnation of textiles with oil-Roccal emulsion; (b) the influence of textile treatment combined with floor oiling on the rate of upper respiratory infections, the carrier rates for streptococci, and the dust and bacterial content of air; (c) the minimal effective concentration of retained oil; and (d) the effect of the washing of treated blankets on their residual oil content and dust-retention properties.

Addendum: While this article was in press, Puck, Loosli, *et al.* reported similar results (*Amer. J. Hyg.*, 1946, **2**, 91–120). This work will be considered in greater detail in subsequent publications from this laboratory.

References

1. Harwood, F. C., Powney, J., and Edwards, C. W. *Brit. med. J.*, 1944, **1**, 615–616.
2. Loosli, C. G., and Robertson, O. H. *Amer. J. med. Sci.*, 1945, **209**, 166–172.

A Multiple Light Source Microscope

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It is often of considerable importance to be able to compare microphotographs of tissue which have been made by light of different wave lengths. With this in mind a setup has been arranged so that this can be accomplished without the necessity of moving the light sources when a change in wave length is desired.

This arrangement is shown in Fig. 1. It can be

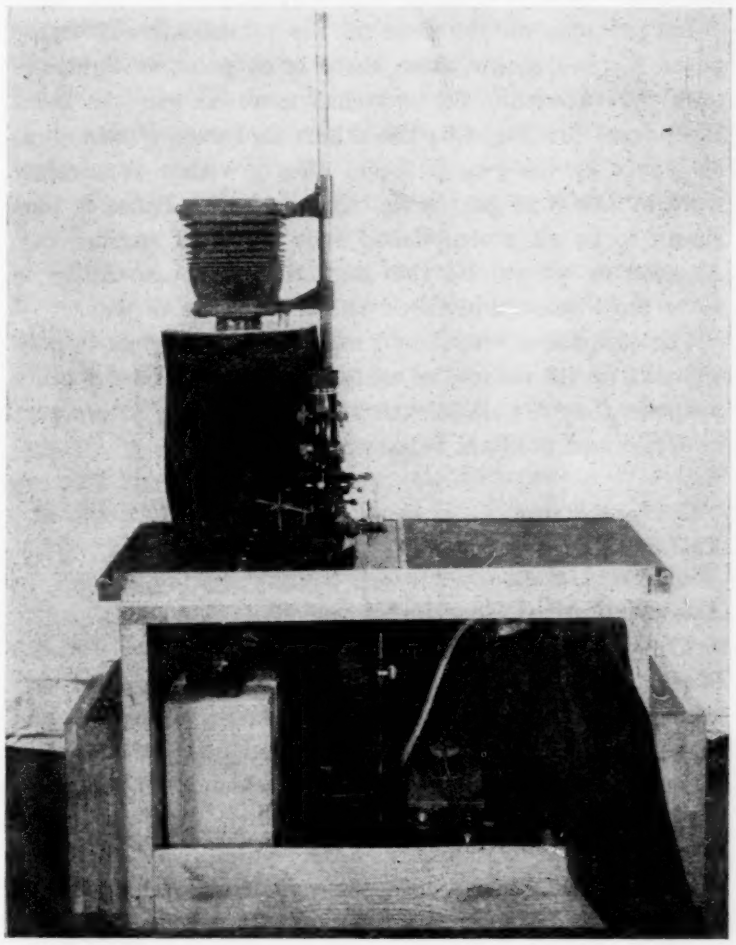

Fig. 1

seen that the light sources are in a row, and the microscope and camera are mounted above on an optical bench. At either end are small black window shades, so that when the microscope and camera are moved from one light source to another, one shade pays out and the other winds up. Once the sources are lined up this never has to be done again. The black cloth draping is necessary in order to protect the eyes from ultraviolet light.

At present pictures can be taken using visible, infrared, polarized, fluorescent (3,600 A.), and 2,537 A. light (*1*).

Reference

1. Lavin, George I. *Rev. sci. Instr.*, 1943, **14**, 375.

Letters to the Editor

On the Need for Social Engineering

The article, "Physical thinking and social problems" (*Science*, 1946, **103**, 717), like many other articles today that tender a solution to the threat of the atom bomb and war, is somewhat beside the point. While the rigorous and quantitative mind may be able to aid in developing social science, such development is superfluous so far as preventing war is concerned. The fundamental knowledge of social structure necessary to bring about peace is relatively simple and well known. What is needed is not so much new theory as social engineering.

Large areas on the face of the planet already enjoy peace because within them there is no point in fighting: each person within the area has more or less the same rights and privileges as the others and may obtain what he wants by his own peaceful efforts within the framework of law that guards the rights of all. Peace is thus shown to be an accomplished fact of social engineering. As soon as we extend this mutuality of opportunity to cover the whole world there will be no cause of war.

The call, therefore, should not be for physicists to help out with social theory, as useful as that may be for other purposes, but for all scientists to take a more active part in social and political engineering.

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Abbreviations of Generic Names

The practice of using abbreviations for generic names is admissible only in cases where it does not lead to confusion. In preparing a review of yeast-like fungi I had occasion to refer to a paper published in the *Journal of Dairy Science*, 1940, Vol. 23, in which the following organisms were discussed: "*O. lactis*," "*Myc. lipolytica*," "*Ach. lipolyticum*," "*Alc. lipolyticus*," and "*Ps. fluorescens.*" Nowhere in the paper were the full generic names given. The author may have been certain of the identity of his organisms, but it is doubtful if many of his readers knew for certain what he had in mind. This paper is not by any means an isolated case, but it serves unusually well to illustrate my point.

"*O. lactis*" undoubtedly meant *Oidium lactis* or *Oospora lactis*, as anyone familiar with the field would deduce. "*Myc. lipolytica*" gave more difficulty. After some consideration it was decided that neither *Mycobacterium*, *Myceloblaston*, nor *Mycoderma* was meant, since *lipolytica* is feminine and each of these genera is neuter, although the last is often but improperly used as feminine. It probably was not *Mycoplana*, *Mycogone*, *Mycocandida*, or *Mycotoruloides*, but this could be ascertained only after a considerable search to find combinations of one of these generic names with *lipolytica* failed. There are many other generic names beginning with "Myc" but only those familiar to me were considered. Probably, but not certainly, the author meant *Mycotorula lipolytica* Harrison. Why did he not so state and why did the editor not insist on it?

"*Ach. lipolyticum*" gave almost as much trouble. Was *Achromatium* or *Achromobacter* among the bacteria or *Achorion* or *Achlea* among the molds meant? These were the only generic names beginning with "Ach," with which I was familiar. Unfortunately, three of them are neuter, as is the specific name. By means of elimination *Achromobacter* was tentatively decided upon.

In the same way it was decided that "*Alc.*" meant *Alcaligenes* and "*Ps.*" meant *Pseudomonas*. The fact that so many bacteriologists use "*Ps.*" to mean *Pseudomonas* and that the combination *fluorescens* is so familiar made this last deduction easy, although there are very many generic names in biology which commence with "Ps."

Either the author of this good paper or the editor of the journal in which it appeared should have seen to it that the full scientific names were spelled out once in the interests of scientific accuracy. Thereafter, abbreviations could well have been used, preferably single capital letters. Many bacteriologists seem to assume that we have official generic abbreviations. We have not.

This sort of thing has been discussed previously in the scientific press, but it can bear repetition. After all, many of us do read scientific papers, and we should like to know what organisms are being discussed. Finally, concerning a certain paper of my own, published about 20 years ago, the only thing that I can say in this regard is: "I acknowledge my transgression, etc."

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"The Little Researcher"

At last, and rightly so, the "Little Researcher" is being accorded some measure of credit and distinction. Carl G. Hartman (*Science*, 1946, **103**, 493–496) speaks strongly on behalf of the too frequently forgotten small college teacher.

Briefly, Dr. Hartman suggests that one or two per cent of the $100,000,000 recommended for the annual budget of the National Science Foundation of the new Kilgore-Magnuson Bill be allocated to the "Little Researchers." He also calls attention to the fact that the universities and colleges are the training schools for research personnel. In his paper, as would be expected, the writer gives considerable space to the contributions made by the small colleges.

It is my firm belief that in the biological sciences unless one carries on some scientific investigation especially, in a small college the setup becomes stagnant. The teacher who uses and holds his college lectures to violate in teaching his own students leaves no outlet for

the expression of individual differences. Prof. John Givler states (*Turtox News*, January 1944, Vol. 22) that "mere orthodoxy is sterile and particularly odious in the laboratory which has to its credit historical laudation for smashing religiosity devoid of spiritual value." This is the kind of thing which through long repetition becomes "dry rot." The indications are that the spirit of a small, thriving college must be intimately tied up with research. Then, too, a research teacher usually leaves a lasting impression upon his students. We may say that this is at least partly due to the personal contact between teacher and student.

Many small colleges with very limited resources carry on a small but very serious research program without neglecting the students. In the case of a heavy teaching load, careful organization of the courses is most important; often the teacher sacrifices his own time and finances. It is noteworthy that Harry W. Greene (*W. Va. St. Coll. Bull.*, February 1946, Ser. 33, No. 1) has compiled two decades of research and creative writings at the college. This type of program, I am sure, is duplicated by hundreds of small colleges.

The undersigned (*Turtox News*, October 1945, Vol. 23) attempted to point out a few of the advantages derived from using living specimens in studying vertebrate embryology. The use of living embryos lifts the course from mere pedantry to one of intense interest and active participation. I quote from the above paper: "Aside from interest it is perhaps the best way to develop a student for future service to humanity, especially should he wish to set up his own experiments or do some form of research."

Finally, it should be emphasized that the "Little Researchers" all over America have a common bond of interest, especially where there are little or no funds set up for research. The undersigned agrees that the small colleges as a whole must not overlook the new Kilgore-Magnuson Bill and must at the same time impress upon Congress that the "Little Researcher" is still an important factor in producing the "Big Researcher."

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Redwood Notes

Of the nearly 50 species of conifers in California the redwood, *Sequoia sempervirens* (Lindl.) Engl., is the most important. Unlike its relation, the giant Sequoia of the Sierra Nevada, which is restricted to about 30 isolated groves, mostly of small size and between 5,000 and 8,000 feet elevation, the redwood occurs, often in great numbers, from Monterey County to the Oregon border, a distance of 450 miles (W. L. Jepson. *Silva of California.* Berkeley: 1910).

As a rule, redwood grows only in areas which are invaded by the ocean fogs. These areas include the regions of heaviest rainfall in the state, the annual precipitation of some stations exceeding 100 inches.

The coastal climate is very uniform with relatively little temperature fluctuation. Thus, at San Francisco there is a difference of only 10° F. in the mean temperature of the warmest and coldest months (60°–50°). As a result of these favorable climatic conditions the growth is almost continuous and the forest is very luxuriant. The rapidity of growth in the young trees may be extraordinary. For example, a young redwood, perhaps 5 feet high, was planted near my house on the Stanford campus in the winter of 1913–14. When 30 years old it was 105 feet high, with a breast-high girth of 10 feet. There has been a very appreciable increase both in height and girth during the past year.

The redwood belt, with an average width of about 20 miles, begins in the Santa Lucia Mountains in Monterey County, where there are a few redwoods in some of the canyons opening to the sea. For the most part the area is too dry to support the redwoods. At the northern limit a few redwoods are found in Oregon above the California boundary. The forest reaches its maximum development in the northern counties, especially Humboldt and Del Norte. In this region, through which the Redwood Highway passes, the traveler can observe many trees more than 300 feet high—one recently measured was 364 feet, probably the tallest tree of any species of which there is an authentic record.

While the heaviest forests are in the northern counties, there are large areas in the mountains south of San Francisco and especially in the Santa Cruz range, site of a State Redwood Park and the "big trees" near Santa Cruz. Redwoods are also still growing within a few miles of San Francisco, the best known of these groves being Muir Woods on Mt. Tamalpais.

The Stanford estate of about 8,000 acres is 32 miles south of San Francisco and extends westward to the base of the Santa Cruz range, where redwoods are abundant. Some of these are included in the Stanford property, especially along the San Francisquito Creek, which forms the northern boundary of the Stanford estate. A solitary redwood, an ancient landmark still standing and known as "Palo Alto" (tall tree), gave name to the Stanford farm where the University is situated, and the name was borrowed for the town of Palo Alto, which adjoins the University property and which was founded soon after the University was opened.

In the heaviest forests of the northern counties the redwood is the only species and may occupy extensive areas as pure stands. It is claimed that the amount of timber yielded from these extensive areas of pure redwood is the greatest known. Jepson states that yields of 120,000 to 150,000 feet per acre are not uncommon, and 480,000 feet have been cut from a single tree.

In the southern forests, e.g. in the Santa Cruz Mountains, the redwood is associated with a number of other species—Douglas fir (*Pseudotsuga*), tanbark oak (*Lithocarpus*), madroño (*Arbutus*), and, outside the redwood belt, a variety of trees which are also associated with the vegetation of the open valley.

A notable feature of the redwood is its remarkable power of regeneration. Unlike most conifers, it develops many sprouts from the cut stump, and some of these shoots soon become trees that replace the parent and restore the forest. Sometimes similar shoots develop

from superficial roots. The very thick bark is resistant to fire, and after all the branches have been burned, the surface of the trunk may soon be covered with a mat of small twigs developed from dormant buds. In course of time, some of these twigs will replace the destroyed branches. Because of the favorable growing conditions in the redwood forest, which permit almost uninterrupted growth, the young forest is soon established.

The redwood probably never attains the enormous age of the Sierra big trees, some of which have been estimated to be 3,000 to 4,000 years old and greatly exceed in bulk the trunks of the largest redwoods. Jepson gives 400 to 1,300 years as the age of the mature redwoods, the maximum diameter of which is 16 feet compared with 30 feet in *S. gigantea.*

During the past years there have been active efforts to save what remains of the original forests—of special note are the activities of the "Save the Redwoods League"—which have resulted in the purchase of large areas of the finest redwoods, especially in northern California. As a result, these unique forests are probably secure for the future.

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Survival Time of Hypertensive Rats Receiving Fish-oil Extracts

The demonstration by A. Grollman (*J. Pharm. exp. Therap.*, 1945, 84, 128) that the blood pressure of animals with experimentally induced hypertension can be reduced by the oral administration of various extracts derived from oxidized oils raises the question as to the beneficence of this form of therapy. It is obviously important to know if the decline in blood pressure is accompanied by any deleterious effects such as are noted following the injection of many noxious agents which are also capable of reducing the blood pressure. We have therefore determined the effect of administering an oxidized crude fish oil on the survival of rats rendered hypertensive by the procedure of Grollman (*Proc. Soc. exp. Biol. Med.*, 1944, 57, 102).

The animals used for the experiment were a piebald strain reared in the laboratory and weighing 150 to 400 grams. A week following the operation on the right kidneys, the animals were divided into two groups, alternately, according to the level of their blood pressure. One group received the normal laboratory diet; the other, the same diet plus the addition of 10 grams of oxidized fish oil daily for the group. Two weeks following the first operation, the left kidneys in both groups were removed. Blood pressures were determined twice a week.

Observations were continued for two months following the nephrectomies. At the end of this period 21 of the control group of 44 animals had died, while only 11 of the 42 rats in the treated group had died. The average blood pressure of the control group was 134; that of the treated group, 129. The observed drop in blood pressure was, thus, apparently insignificant, due to the relatively small amount of activity present in the doses of oil used, as well as to the fact that the average blood pressure of the animals was not greatly elevated above normal.

A more convincing experiment was carried out on a group of 24 mice, the right kidneys of which were constricted and the left extirpated. Half of this group was treated with a more potent extract than was available in the case of the experiment on rats, which probably accounts for the better response observed. Of the 12 control animals, 10 had died at the end of a six-week period of observation, compared to only 2 in the group of 12 treated animals.

The experiments cited suggest that the administration of extracts of oxidized fish oil prolongs the life of animals with chronic hypertension.

The work described was supported by grants from the John and Mary R. Markle Foundation. I am indebted to Dr. Grollman for supplying the oils used in these experiments and for aid in performing the operations.

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Logic and the Science Curricula

Mr. Churchman (*Phil. Sci.*, Vol. 12, 158) has pointed out that it is possible to enlarge our formal theories of logic so that they may meet with actual observations by including the between-group and within-group variance concept of the statistician in the formal theory. He might also have pointed out that the means of closing this gap between formal logic and the data of observation have been at hand since the concept of constancy of measured results through statistical control was introduced 20 years ago. The slowness with which this concept has penetrated the natural sciences, both biological and physical, is bewildering in this day of rapid progress. Perhaps it is to be expected in the physical sciences, where, due to the relative ease with which their experimental procedures can apparently be controlled, there is some smugness about the need of any statistical control. Mr. Kosolapoff (*Science*, 1946, 103, 235) has done well to call attention to the fact that this control is not as effective as it appears.

The reason that many scientists reject the role of statistics as essential in the experimental method may be due to their failure to recognize the logical implications stemming from the fact that the value of all research lies in its significance for the future. This would indicate a serious deficiency in our science curricula, especially at the graduate level. Expectation that the student will acquire by spontaneous impregnation from his laboratory courses or from his elders a knowledge of the logic of the so-called scientific method is not realized; it is necessary that he take at least one course in logic and one in the philosophy of science. In the great majority of educational institutions this is not the case, even though the Ph.D. degree may be the reward for three years labor in science.

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Book Reviews

A bibliography of infantile paralysis, 1789–1944: with selected abstracts and annotations. **Morris Fishbein. (Ed.) (Compiled by Ludvig Hektoen and Ella M. Salmonsen.) Philadelphia: J. B. Lippincott, 1946. Pp. 672. $15.00.**

The National Foundation for Infantile Paralysis is to be congratulated for having sponsored the preparation of this monumental bibliography, which now provides the physician and research worker with a most valuable tool in their battle with this dread scourge.

Much has been written of the rate at which scientific literature accumulates and how difficult it is for the scientist to keep up with it. A glance at this list dramatically illustrates the point. A total of 8,320 references has been included. Of this total, 805 references suffice to record the literature for the first 111 years covered in this book. From 1900 to 1944, 7,515 references appear, and of this number 2,468 papers appeared in the 10-year period, 1934–1944. The curve of production is thus seen to be a very steep one. Its rate of climb was only slightly retarded during the war years, and one may confidently predict an acceleration in the publication of studies on the subject of infantile paralysis in the decade ahead. It is precisely this increase not only in the rate but also in the volume of publication which emphasizes the importance of a compilation such as we now have. It is only necessary to scan the citations listed to note that the literature on this one disease is scattered through numberless journals published in many languages. The almost hopeless task of working through this vast mass of printed material has now been markedly simplified by the cumulation into one volume of practically the entire literature on poliomyelitis. Thus, the investigator is now provided for the first time with a base line from which he may plan new researches. In addition, the aggregation and juxtaposition of titles may provide glimpses of relationships between facts hitherto unobserved because of the diffuseness of the literature.

The references in this bibliography are arranged chronologically, and abstracts of the more important works have been provided. Almost all titles in foreign languages have been translated into English, and author and subject indexes have been included.

In a work as well arranged and printed as this one it is a pity that the editor and compilers did not see fit to give inclusive pagination in their citations. It is often very useful for an investigator to know whether the reference he seeks is a 2-page note or a 50-page monograph. It is to be hoped that in the supplements which are promised this defect will be corrected. These supplements, incidentally, will include the literature from abroad which, because of the war, was unavailable to the compilers.

In conclusion, the reviewer hopes that this work not only will be instrumental in making possible further progress toward the conquest of infantile paralysis but will stimulate the production of similar guides to the literature of other diseases, such as cancer.

MORRIS C. LEIKIND
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Inside the vacuum tube. **John F. Rider. New York: John F. Rider, Inc., 1945. Pp. xvi + 407. (Illustrated.) $4.50.**

The author of this text is well known as a writer and publisher of a number of books on elementary radio theory widely read and used by radio servicemen and technicians. He states that this book is an effort to present the elements of the theory and operation of basic types of vacuum tubes. In order to simplify the presentation, only the minimum of mathematics has been included.

In spite of the simplified presentation, the text is quite thorough in its treatment of the vacuum tube, no significant features of vacuum-tube operation being neglected without such omissions being clearly indicated. The explanations throughout the text are quite accurate from a technical standpoint. It is found, however, that the problem of presenting technical material without recourse to mathematics and the necessity for very detailed explanations of all curves and graphs frequently lead to quite complicated sentences and rather heavy reading. Probably this is unavoidable, but it means that the text must be studied slowly and with great care in order to understand it completely.

Throughout the text the author uses the electron convention of current flow, showing the current flowing from the cathode to the positive plate. This is very convenient in explaining vacuum-tube phenomena and might be more widely used by others. On circuit diagrams, current flow is illustrated by means of electron figures, with feet and arms, running around the circuit. Because these images are rather large, they tend to obscure the circuits, and arrows might have served as well. Curves and figures are frequently presented on both sides of a single page to help the reader who would otherwise be forced to turn the page to refer to them—another innovation which should have wider use.

The author devotes considerable space to a discussion of the electrostatic field within the vacuum tube. This is unusual, but helpful, in an elementary text of this sort. Three stereoscopic illustrations are included, but the reviewer feels that they do not contribute greatly to a better understanding of the text.

Because of the author's refusal to yield to the temptation of making inaccurate statements for the sake of simplicity, this book may confidently be read by a beginner or one new in the field with the assurance that the material presented is an accurate explanation of vacuum-tube phenomena.

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Craniometry of Ambrym Island. **Wilfrid D. Hambly. (Fieldiana: Anthropology, Vol. 37, No. 1.) Chicago: Chicago Natural History Museum, 1946. Pp. viii + 150. (Illustrated.) $2.75.**

The material of Dr. Hambly's study consists of a series of 20 male and 11 female skulls, from Ambrym in the New Hebrides, which he treats with great thoroughness. He provides photographs, raw data, contour drawings, and tabulations of differences in mean measurements from other series, with their statistical controls, prefacing the above with general discussions of measuring technique, instruments, statistical methods, sex differences in crania, and sex ratios, and appending special sections on general racial differences in jaws and teeth and on interracial standard deviations. If Dr. Hambly seems to be taking a long run for a fairly short jump, this is perhaps not his fault, because the methods of physical anthropology lend themselves readily to overindulgence.

The significant part of the study is a metrical comparison, in order to determine the racial connections of the Ambrym Islanders, of the skulls with a group from New Britain and another from New Guinea, which indicates a resemblance, especially with the former. Dr. Hambly also compares the Ambrym skulls with East Africans (actually 55 crania from a single tribe), with pooled native Australians, and with pooled Polynesians (all groups except Easter Island, which is held to be too aberrant). Because of the relative number of average measurements which do not differ to a markedly significant degree in a statistical sense (6 × probable error), he concludes that the Ambrym skulls have a relationship with the "Australoid" and "Negroid" types, and even with Polynesians. But this research is unconvincing because the series used for comparison are chosen or made up in very dubious fashion. Also, no really workable conclusions are provided, although much has been written on the subject of Melanesian and Oceanic relationships. Above all, in spite of his obviously conscientious reading of the literature, Dr. Hambly does not even mention the question of pygmies or Negritos in Melanesia, for which the New Hebrides may be the critical area, and which is so important to the racial history of the Pacific, of the Negro family, and of mankind in general. Speiser dealt with the matter at some length in a paper on Espiritu Santo, and Hambly's own photographs, both of living Ambrymese and of crania, themselves suggest the point.

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Colloid chemistry: theoretical and applied. **Vol. VI: *General principles and specific industries; synthetic polymers and plastics.* Jerome Alexander. (Ed.) New York: Reinhold, 1946. Pp. vii + 1215. (Illustrated.) $20.00.**

The 71 papers in this volume are "devoted mainly to applications of colloid chemistry involved in the processes and the products of industry, or of value to technology and technologists. Including a few theoretical papers, they fall into two groups: 38 papers dealing with specific industries or industrial operations; 3[illegible] papers centering about synthetic resins and plastics. A general article on nuclear fission and atomic energy is also included."

The first group of papers is led by Harkins' "The Surfaces of Solids and Liquids and the Films That Form Upon Them. Part II: Solids and Adsorption at the Surface of Solids or Liquids." Also included in this group are articles by various authors, written primarily from the viewpoint of the industrial colloid chemist and covering the following subjects (titles abbreviated): Strength and Failure in Brittle Solids; Mass Spectrometer; X-ray Spectrometer; Electron Microscopy; Dichroic Polarizers and Applications; Clay Minerals and Clay Films; Catalysis; Surface Active Compounds; Adhesives; Soybean Lecithin; Insecticides; Electrical Precipitation; Dispersions of Finely Divided Solids; Thixotropy; Rubber Latex; Synthetic Rubber; Carbon Black; Colloidal Graphite; Soil Stabilization; Flotation; Drilling Fluids; Colloidal Factors in the Petroleum Industry; The Technology of Resolving Petroleum Emulsions; Lubricating Greases; Colloidal Behavior in Metals and Alloys; Electrodeposition of Metals; Surface Treatment in Fusion Welding, Pressure Welding, Brazing, and Soldering; Physical Chemistry of Dyeing; Colloidal Factors in Laundering; Phycocolloids; Luminescent Paints; The Skin and Its Technological Hazards; Solid/Liquid Separations; Centrifugals as Applied to Colloids; Adsorption from Solution by Activated Carbon; Vapor Adsorbent Carbons; and Water-soluble Lignin.

The second, more homogeneous part of the book deals with the various classes of synthetic polymers and plastics, each group being treated in one of about 30 separate articles, from nitrocellulose, viscose, and acrylic resins to nylon, silicons, and ion exchange resins.

Because of the nature of the book, the articles are very heterogeneous as to viewpoint, length, thoroughness, completeness, and competency and literary skill of the authors. Short and rather superficial sketches without adequate references to the literature alternate with carefully written articles with extensive lists of carefully selected references. Examples of the latter group are the above-mentioned article by Harkins, Valko's "Physical Chemistry of Dyeing," and last but not least the monograph-like (108 pp.) review on "Phycocolloids: Useful Seaweed Polysaccharides," by C. K. Tseng.

The wealth of information contained in this volume makes it a necessary addition not only to the chemical libraries of colleges, universities, and larger industrial laboratories, but also to the bookshelves of any small firm dealing with industrial colloids.

The print of the book, although clear, is too small for prolonged reading. The lack of alphabetic arrangement of the references of some of the papers is a distinct disadvantage.

It is hoped that the editor may find an opportunity to compile a much needed General Index for all the volumes of his *Colloid chemistry* and to incorporate it in the next volume which he may publish.

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